MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2 2019/2020

TRT 3241- REAL-TIME SYSTEMS

(All sections / Groups)

13 March 2020
3.00 p.m. – 5.00 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This examination paper consists of 4 pages (including the cover page) with 5 questions only.
2. All questions carry equal marks. The allocation of marks for each question is given in the paper.
3. Answer **ALL** questions.
4. Write your answers in the answer booklet provided.

Question 1 [10 marks]

a) Define a real-time system.
b) Consider an A/D converter with a full-scale measurement range of -5 to 5V and a resolution of 16 bits. How many quantization levels are there? What is the maximum quantization error? Show all steps.
c) Explain the **THREE** components of real-time operating system (RTOS) kernel.
d) *Task Control Block* (TCB) is a data structure that represents the CPUs of a system. The TCBs provide space for storing the contents of the CPUs' registers R_0 to R_n. Moreover, each TCB has a pointer to the TCB that represents the next CPU. Illustrate the TCB concept.
e) Explain the difference between '*Ring Buffer with Get Semaphore*' and '*Ring Buffer with Put Semaphore*'.

[1 + 2 + 3 + 2 + 2 marks]

Question 2 [10 marks]

a) Explain the type of services provided by the following components:
   i. TCP/IP protocol stack
   ii. File system
b) Define an interrupt. What type of exception is an interrupt? Justify your answer.
c) Explain **THREE** uses of interrupts and exceptions.
d) Differentiate between real-time clocks and system clocks.
e) State **FOUR** functions of a programmable interval timer (PIT).

[2 + 2 + 3 + 2 + 1 marks]

Question 3 [10 marks]

a) State **TWO** main functions of I/O subsystem.
b) List the steps to accomplish the uniform I/O operations at application-level.
c) State **THREE** design requirements on memory management system.
d) What is **ONE** limitation of memory compaction?
e) With the help of a diagram as an example, describe fixed-size memory management technique.

[2 + 2.5 + 1.5 + 1 + 3 marks]

Continued...

Question 4 [10 marks]

a) The following five tasks are to be scheduled on a single processor pre-emptively. As a convention, a greater priority value means a lower priority. Thus, T_1 has the highest priority and T_5 has the lowest priority.

Task	Priority	Released at	Execution time	Resource usage
T_1	1	6	3	[1, 2) uses X
T_2	2	4	5	[1, 3) uses X; [2, 3) uses Y
T_3	3	3	2	None
T_4	4	2	1	None
T_5	5	0	5	[1, 4) uses X

Construct the schedule when the priority inheritance protocol is applied for resource access protocol.

b) A system contains five tasks. There are three resources X, Y, and Z. The resource requirements of the tasks are specified as follows:

T_1 : $[X;2][Y;4]$

T_2 : $[Z;1]$

T_3 : $[Y;3][Z;6]$

T_4 : None

T_5 : $[X;4][Z;2]$

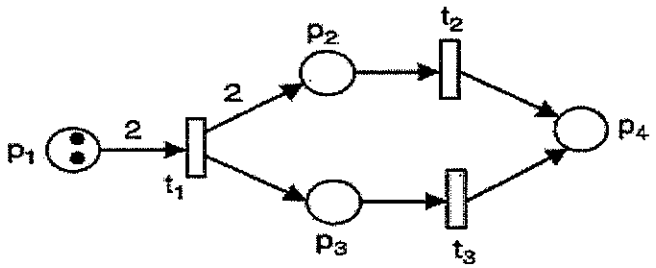
The tasks are indexed in the decreasing order of priorities and scheduled with the priority ceiling protocol. Find the maximum blocking time for each task.

[7 + 3 marks]

Continued...

Question 5 [10 marks]

a) Construct the reachability tree of the following Petri Net.



The reachable markings are given as follows:

$M_0 = (2, 0, 0, 0)$,
$M_1 = (0, 2, 1, 0)$,
$M_2 = (0, 1, 1, 1)$,
$M_3 = (0, 2, 0, 1)$,
$M_4 = (0, 1, 0, 2)$,
$M_5 = (0, 0, 1, 2)$,
$M_6 = (0, 0, 0, 3)$.

b) Consider a cruise control (CC) system in an auto. The CC controller has four buttons: *CC*, *Set*, *Cancel*, and *Resume*. To start any cruise control functions, the *CC* button has to be pressed, which brings the cruise control system from the *Off* state to the *Armed* state.

- At the *Armed* state, if the *Set* button is pressed, the system enters *Speed Control* state; if the *CC* button is pressed, the system goes back to the *Off* state.
- At the *Speed Control* state, if the *Cancel* button is pressed or the brake pedal is applied, the system changes to the *Cancelled* state; if the gas pedal is applied, then the system changes to the *Override* state.
- At the *Cancelled* state, if the *Resume* button is pressed, the system goes back to the *Speed Control* state; if the *CC* button is pressed, it goes back to the *Off* state.
- At the *Override* state, if the *Resume* button is pressed, the system goes back to the *Speed Control* state; if the *CC* button is pressed, it goes back to the *Off* state; if the *Cancel* button is pressed, it switched to the *Cancelled* state.

Construct the behaviour of the cruise controller with a Petri Net.

[3 + 7 marks]

End of Paper.